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Abstract

This study aims to analyse the surface sediment of Batroun coastal area in North Lebanon in order to reveal the integrating impact of Selaata chemical plant on its biological properties. Sediment samples were collected with cores by diving at 12 stations in summer period between mid July and beginning of August 2003. The values of the hydobiological parameters in the first 3 cm were ranging respectively between: 4.17 to 7.9 for pH, 0 to 171 mV for Eh,, 0 to 0.94 $\mu g.g^{-1}$ for chlorophyll a and 24 to 4166 ind.10 cm^{-2} for meiofauna. The results showed that there was a reverse relationship between chlorophyll a and meiofauna and that Batroun marine area could be separated in two main areas of influence The first area includes the stations located in front of the main north-western emissary and where the sediments were more acid and less oxygenated with strong odour of hydrogen sulphide accompanied with high chlorophyll a contents and low numbers of meiofauna. The second area is consisted of stations located to the south or far offshore from the plant and where the sediments are characterized by lower acidity and higher redox potential with low chlorophyll a concentrations and higher population of meifauna. Exception could be found in some stations like M8 and M 13 that presented particular cases. The impact on the biological indices was limited to plant proximity where conditions were more perturbing and the variability in the concentrations of chlorophyll a and the numbers of meiofauna were not depending on sediments compositions but on the nature and toxicity of particulate matters rejected out of plant's emissaries such as the phosphogypsum.

Introduction

Sediments play a major role in the estimation of marine environment contamination. However, they provide information on the source and the dispersion of contaminants, and a long-term integration of the environmental impact in dynamic and complex surrounding (Birch *et al*., 1999) by smoothing the fluctuations of different characteristics, in space and time. Indeed, they represent the final destination of the major part of the terrestrial compounds of natural or human origin (Förstner, 1976). Also, their analysis plays a basic environmental role (Meiggs, 1980; Eyre and McConchie, 1993) in detecting the contaminants not being detected by water analysis (Pardo et al., 1990). The destiny of particles to which a contaminant is associated is much better determined by the dynamics and movement study of sediments than by water study alone (Dyer, 1989; Balls, 1990).
Batroun is a coastal city located 50 Km to the north of the Lebanese capital Beirut. Its marine environment is subjected to the influence of two continental inflows: one natural but seasonal Al-Jaouz River's and the second artificial but permanent Selaata chemical plant. Al-Jaouz is a seasonal river of 25 Km length ending on the northern coast of Batroun city (B.E.H.T, 1995). It becomes active in winter and spring with an average annual flow of 74 Million m^3 and completely dry in summer and autumn. Selaata chemical plant is classified among the first ten industrial societies in Lebanon (Ecodit-Iaurif, 1997). It is located 300 meters to the north of Al-Jaouz River's mouth. Its annual capacity exceeds the 400 million tons of various products like simple superphosphate, superphosphate triples, the phosphoric acid, the sulphuric acid and the aluminum sulfate (Al-Hajj and Muscat, 2000). The factory of Selaata uses 840 T of rocks of phosphate per day (Abboud and Dargham, 1998). Great quantities of by-products are discharged directly in sea water (Abboud and Attallah, 1996) without any pretreatment.
The impact of these two continental sources creates continuous variations of the hydrobiological characteristics of Batroun marine area (Fakhri *et al*., 2005). The networking strategy that was adopted in water analysis and that was based on periodic samplings at fixed stations has provided results on the existence of zones of influence that are able to superimpose according to weather situations, but nevertheless it has also drawn limits from north to south while following the coastal aspects. During each mission the information recapitulated by this strategy was limited in time, while it was necessary to complete these data by studying an environment that is able to integrate the various fluctuations in time and space. In order to reveal the impact of Selaata chemical plant emissions on the marine benthic environment, the biological properties of sediments in several stations of Batroun marine area were analysed. One of the difficulties encountered in this work, for the interpretation of the data, is the fact that these sediments are often located at low depths. Therefore, they are probably subjected to consecutive perturbations from the active hydrodynamic processes which can disturb, significantly, the vertical structure of the sediments. In what follows, the composition of surface sediments, collected at the same stations where sea water samples were analyzed monthly, are going to be studied.

Material and methods

Adopted strategy

Between mid-July and the beginning of August 2003, sediments were collected by diving at 12 stations (M1 to M10 and M12 to M13) (figure 1; table 1) of the coastal zone of Batroun (Northern Lebanon), using PVC cores of 30 cm length and 3.7 cm diameter. At each station, four cores were collected: one for the study of sediments grains composition, another for the determination of inorganic phosphate concentrations and chlorophyll a contents, and two carrots for meiofauna groups counting. At the laboratory, the first 3 centimetres of sediments were freeze-dried for analysis. pH and oxydo-reduction potential (Eh) were measured in situ by direct penetration of both probes into the core. It is important to mention that Eh was only measured up to station M8, after that the only probe available was broken and no further measurements were done.

Adopted methodologies

Determination of grain-size composition : For each station, the whole content of the core was placed in a Pyrex cup and dried in oven during 3 days at a temperature of 105°C. Particles sizes < 0.8 mm were determined by a laser particle-measurement instrument Malvern Sizer and the fractions > 0.8 mm by simple sifting_and weighing. The granulometry is expressed as a percentage of five fractions: fine fraction (clay + silt < 63 µm), fine sand (63 µm <very size sand + fine sand <250 µm), medium size sand (between 250 µm and 500 µm), coarse sand (between 500 µm and 1000 µm) and gravel (>1000 µm).

Measurements of chlorophyll a: Chlorophyll a sediments' contents were determined by high performance liquid chromatography (HPLC). Chlorophyll a extraction is done while placing approximately 1 g of the sediments in 2 ml of acetone (90%) then preserved in darkness at 4°C during 24 hours. The solvents and the gradients are adapted according to Mantoura and Llewellyn (1983) method. The quantification of pigments contained in the extracts is carried out from pigments' standards.

Extraction and numeration of meiofauna: The sampled sediments are transferred in polypropelene plastic tubes then fixed with formaldehyde (5%) and neutralized with the hexamethylene tetramine (10 g per litre of formaldehyde of 5%). At the laboratory, the samples are coloured during 24 hours using a Pink Bengal solution which facilitates the sorting. Then, the contents of the tubes are versed on two sieves of respective meshes, 1 and 0.04 mm. The sieve of 1 mm permits to eliminate the sedimentary particles as well as the macrobenthos and the second of 0.4 mm allows extracting the meiofauna by successive centrifugations in 100 ml tubes for the muddy sediments. In this study, only the enumeration of great taxonomic groups is going to be taken into consideration.

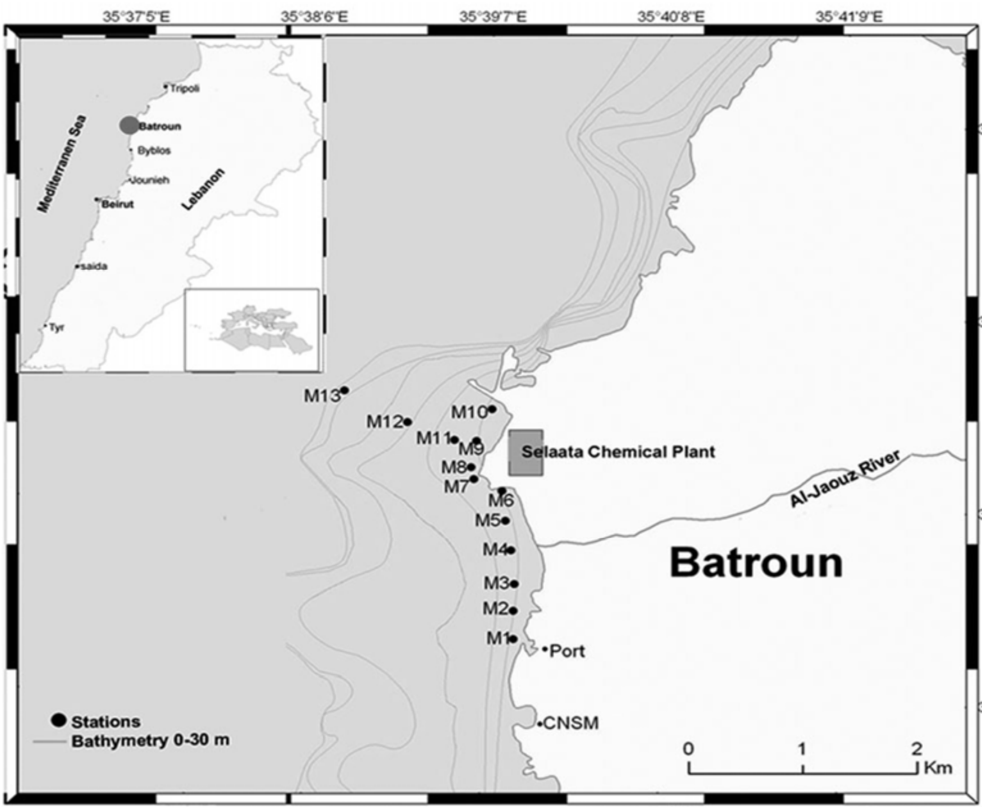

Fig. 1. Sampling stations in Batroun marine area (North Lebanon)

Table 1. Description and coordinates of sampling stations

Stations	Coordinates	Depth	Distance from the Plant
M1	N 34° 15,533'; E 35° 39,361'	10 m	750 m south of the southern emissary
M2	N 34° 15,684'; E 35° 39,357'	10.5 m	590 m south of the southern emissary
M3	N 34° 15,824'; E 35° 39,359'	7.5 m	450 m south of the southern emissary
M4	N 34° 16,003'; E 35° 39,339'	6 m	265 m south of the southern emissary
M5	N 34° 16,160'; E 35° 39,304'	6 m	110 m south of the southern emissary
M6	N 34° 16,317'; E 35° 39,280'	5 m	25 m south of the southern emissary
M7	N 34° 16,377'; E 35° 39,119'	11 m	200 m south of the west-northern emissary
M8	N 34° 16,440'; E 35° 39,102'	6 m	140 m south of the west-northern emissary
M9	N 34° 16,579'; E 35° 39,132'	5m	80 m west of the west-northern emissary
M10	N 34° 16,748'; E 35° 39,214'	4 m	170 m north of the west-northern emissary
M12	N 34° 16,672'; E 35° 38,734'	16 m	500 m west of the west-northern emissary
M13	N 34° 16,834'; E 35° 38,370'	24m	850 m west of the west-northern emissary

Results

Sediments grain-size distribution

Sediments grain-size distribution of each station is illustrated by figure 2.

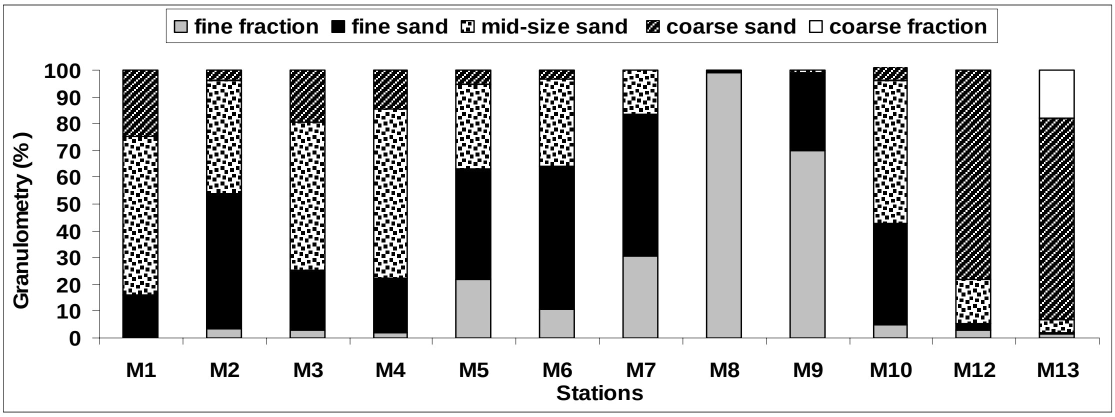

Fig. 2. Grain-size distribution of sediments in Batroun coastal stations

At the port exit, the sediments of station M1 are almost consisted of sand, with more than 59% of medium size sand. The same situation is found for both stations M3 and M4 which are under the direct influence of the river and where the proportion of medium size sand was 55 and 63% respectively. At station M2, the fine sand fraction was better represented (55%). In these first four stations, sand (fine sand and medium size sand) represented more than 78% of the total grain-size distribution. While approaching the chemical factory (from M5 onward), the percentage of medium size sand decreased and that of the fine fraction (silt + clay) increased. At the stations (M7 to M9) subjected to the direct influence of the western and north-western emissaries and where dominates the fine fraction (silt + clay). It is noticed that the two fractions, fine sand and medium size sand, are still present at station M7 but they are missed at station M8, whereas at the station M9 only medium size sand is present. At station M10, the fractions " fine sand" and "medium size sand" increased, and the fine fraction decreased (<5%). The sediments of the furthest stations M12 and M13 are characterized by the predominance of the coarse fraction, especially coarse sand.

Variations of pH and Eh (oxydoreduction potential)

The variations of pH and oxydo-reduction potential (Eh) of sediments are illustrated in figure 3. pH values increased continuously from 7.26 at station M1 (Batroun port exit) till reaching a maximum value of 7.90 at station M4. From station M5 onward, the pH decreased continuously from 7.40 till reaching a minimum value of 4.17 in the sediments of station M8. For both stations M9 and M10, the pH was weak, 7.12 and 7.32 respectively, while it was stronger at the furthest stations M12 (7.53) and M13 (7.77). The sediments of stations located closer to the fertilizers' plant (M5 to M10) were more acid that those located further. Eh values fluctuated between 131 mV at station M1 and 170 mV at station M6. Whereas, the Eh value was electronegative (-45 mV) at station M7 and it was slightly positive (27.40 mV) at the station M8. Unfortunately, the Eh values were incomplete from station M9 till station M13 since the only oxydoreduction probe was not functional any more.

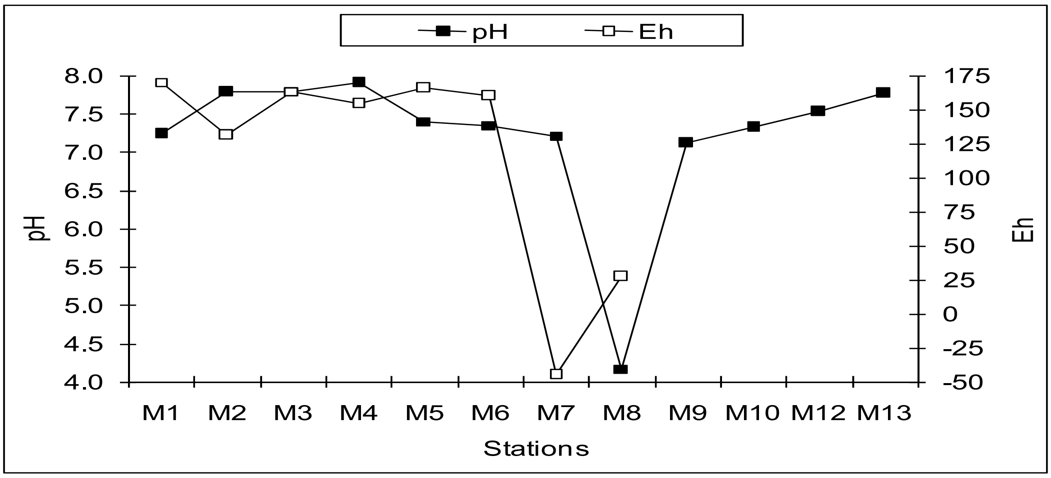

Fig. 3. Variations of pH and Eh (mV) in surface sediments

Biological fraction in surface sediments (chlorophyll *a* and meiofauna)

Chlorophyll *a* concentrations and meiofauna populations' densities in surface sediments are illustrated in figure 4 and the percentage of meiofauna groups at each station is represented by figure 5.

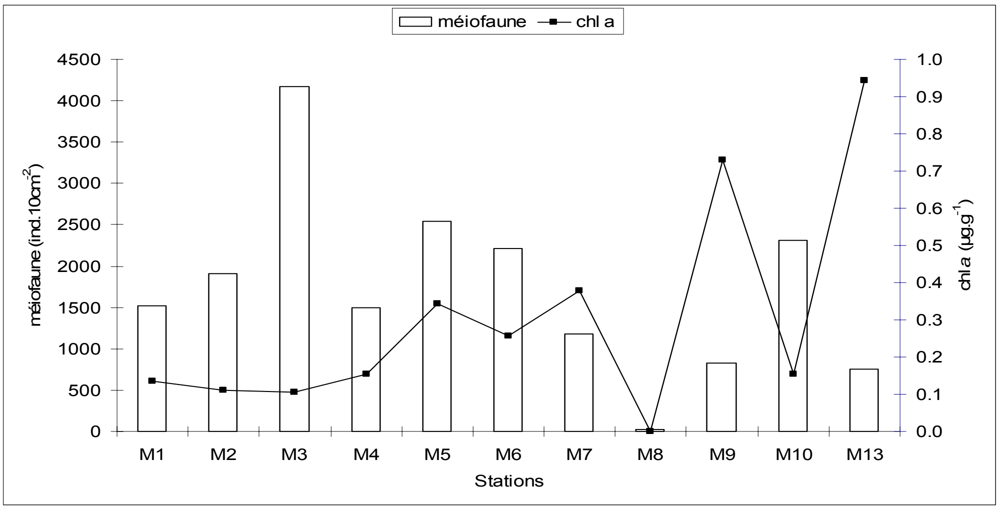

Fig. 4. Distribution of meiofauna densities (ind.$10cm^{-2}$) and chl *a* concentrations ($\mu g.g^{-1}$) in surface sediments

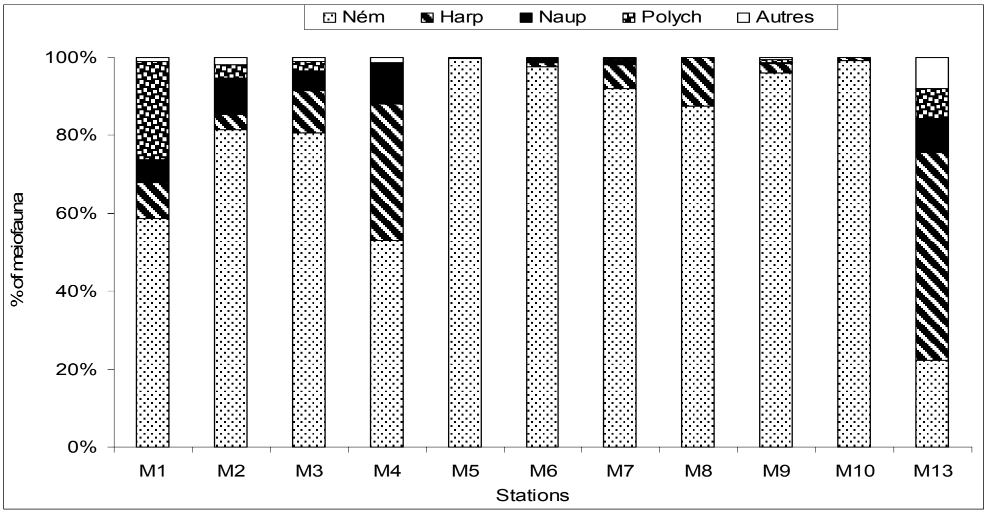

Figure 5: Percentage of essential groups of meiofauna in surface sediments

Chlorophyll *a* concentrations lied between a maximum of 0.94 $\mu g.g^{-1}$ (M13) and zero value (M8), with an average concentration ± standard deviation of 0.30 ± 0.29 $\mu g.g^{-1}$. Where as, meiofauna groups numbers varied between 24 at station M8 and 4166 ind.10 cm^{-2} at station M3 with an average value ± standard deviation of 1721 ± 1107 ind.10 cm^{-2}. The group of nematodes was dominant in all the station, except in station M13, where its percentage fluctuated between 99 % at station M5 and less than 20 % at station M13. The polychaete group was well present at station M1 (25%) and the group of harpacticoid was dominant at station M13 (52%).

Discussion

The predominance of fine particles in front of the west and west-northern emissaries reveals a large rate of sedimentation. This does not correspond to the fact that the great composition in fine fraction is especially localized beside the rivers whose strong flows create variations in the composition of the silts like it was shown by Balasubrahmanyan (1961) or by Alliot *et al.,* (2003) and Younes *et al*., (2003) in front of the Rhône River. Therefore, there is a strong originality if compared to what is in general met in the cases of more active rivers with permanent flow, where the changes in the sediments are especially associated to the extension of river's plum dilution. This is explained, undoubtedly, by the fact that Al-Jaouz River is only active during one part of the year whereas the permanent activities of the chemical factory with its sources of discharges increase the proportion of the fine fraction in a part of Batroun marine region. Also, the low depth of the studied stations exposes the sediments to continuous hydrodynamics. For example, at the stations located in front of the port's exit and the river's mouth, boats navigation and water movement move the fine fraction offshore. A river transports to the sea great quantities of sand, organic matter, clay and especially silt. The larger particles, including the sand, fall quickly at the bottom in the proximities of river's mouth, while the fine particles (clays, silt and organic matter) float longer time before settling on the bottom (Dyer, 1979; McComb et al., 1998). In the case of the Al-Jaouz River, it emerges in a shallow marine zone of very active hydrodynamics, where the suspended particles do not have time to sediment and they are transported far away from the coast to the large. The sediments' grain-size distribution gave a clearer idea on the permanent activities of the Selaata fertilizers plant (very important source of fine particles). So this fine fraction does not come from a natural sedimentation process, but from the rejection of particulate matters out of the factory. The fact that these fine particles are not transported and dispersed very far is, undoubtedly, related to the low flow of the factory rejections in comparison with the intensity of the river discharges. However, the presence or the absence of this fine fraction will play a part in the retention of the organic matter by the sediments. The results obtained have made it possible to deduce that Al-Jaouz River's contribution in fine fraction is very weak in comparison with that of Selaata chemical plant.

It is noticed that in these samples of sediments integrated on a 3 cm thickness, the pH values were definitely lower than those measured in sea water. The comparison between sea water pH (annual averages at the fixed stations) and the sediments pH did not reveal any significant relation ($P>0.05$; $k=10$). For example the lowest average of sea water pH was measured at station M6, whereas for the sediments the lowest pH value was measured at station M8. This shows that the acid thrown out of the factory does not act directly on the sediments. For example, at station M6, water with low pH could not have a significant effect, in-depth, at sediments level, because it would be diluted by the buffer effect of sea water (Darmoul *et al*., 1980). However, the pH variations are, in general, weak between the interstitial water and the overlying water, thus in an equilibrium situation (Laborde and Romano, 1983). At station M8, the sediments are strongly acid due the rejections of suspended particles and solid masses soaked with acid and where the exchange with the surrounding marine water remains difficult. As a quick view, the sediments pH is ranging between 7.68 and 7.90 at the stations associated with coastal water and at those close to the river's mouth. On the contrary, at stations located in the influence of factory's zone, the sediments' pH is globally lower and even very low between 7.32 at station M10 and 4.13 at station M8. The sharp drop in sea water pH of water, that was noted at stations M6, M9 and M10 (Fakhri *et al*., 2005) and that seemed to be limited in space, showed a wider influence in the sediments as a signature of the industrial activity of the factory. The pH values measured in surface sediments of these stations, except for the stations under the influence of the fertilizer plant, are close to the values normally found in surface sediments of a ″healthy zone″. For example, the surface sediments pH values of Revellata bay "Calvi - Corsica" vary between 7.46 and 7.91 (Gobert *et al*., 2003). According to what was shown (Fakhri *et al*., 2005), the station M6 presented the lowest average of water pH (7.76), which is not the case in the sediments where the low pH values were recorded at the stations exposed to emissaries coming out of the western and north-western walls of the factory. A very highly significant reverse correlation ($r= -0.85$; $P<0.001$; $k=10$) was found between the sediments pH and their composition in fine fraction (Fig. 7). This could be explained by the fact that acid water rejected out of the southern emissary is deprived of particulate matters, and it is diluted with sea water (buffer effect of sea water) without affecting seriously the sediments. Otherwise, the north-western emissary rejects acid water rich in suspended particles. These flocculating particles, soaked with acid, decant (El-Alami *et al*., 1998), and the exchanges between the acidic interstitial water of these blocks of fine particles and the overlying marine water slow down because of the fine fraction's small porosity (Laborde and Romano, 1983); these processes could have lowering effect on sediments' pH values. Thus, the oxydoreduction potential showed that the sediments in all the stations located to south of the factory are well oxidized when compared with other sediments of the Mediterranean. For example, the surface sediments Eh values of Revellata bay of "Calvi - Corsica" vary between 78 and 106 mV (Gobert *et al*., 2003). While the sediments of both stations (M7 and M8), exposed to the direct rejections of the factory, are in a state of reduction if compared with the sediments of the stations located out of its influence. It is to be mentioned, that the sediments of the stations exposed to the western rejections of the factory (M7, M8 & M9) had a strong odor of hydrogen sulphide, which explains their strong reduction. According to Laborde and Romano (1983), the reduced sediments are, in general, finer in grain-size composition, and the sandy spots present different physicochemical conditions with higher pH and Eh values (Gobert *et al*., 2003). This explains the decline in the oxydoreduction potential values while moving towards the factory, accompanied with an increase in the fine fraction (silt + clay) starting from station M7. At stations M7 and M8, the Eh was very weak, close to 0 mV, which shows the absence of dissolved oxygen and the presence of hydrogen sulphide. This situation creates the anoxic state of the sediments (Daumas *et al*., 1975; Goedicke and Sagebiel, 1976; Romano and Laborde, 1983) which is well confirmed by the strong odor of sediments at stations M7, M8 and M9. It is also noticed the presence of a relationship between pH and Eh of the sediments of stations under the direct influence of the chemical plant. These stations showed the lowest pH and Eh values.

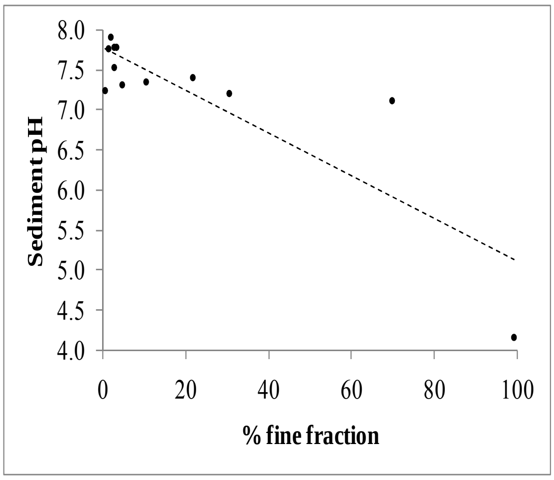

Fig. 7. Correlation between surface sediments pH and % of fine fraction (r= -0.85 ; P<0.01 ; k=10)

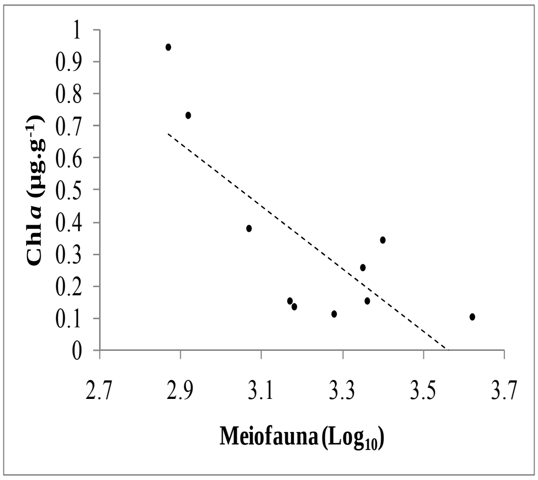

Fig. 8. Correlation between meiofauna densities ($\log_{10}$) and chlorophyll a (µg.g^{-1}) contents in surface sediment (r= -0.77 ;P<0. 01 ; k=8)

As Chlorophyll a and meiofauna are biological indices subjected to seasonal variations, it should be mentioned that these samples were collected in summer.
Except for station M8 where no trace of chlorophyll a was detected, it is noticed that stations located under plant's influence (M5 to M10) (0.380 ± 0.25 µg.g^{-1}) presented higher concentrations than those located out of this influence (0.171 ± 0.1 µg.g^{-1}). Also, it is remarked that chlorophyll *a* contents decreased slightly between M1 and M3, and they increased clearly from M3 to M5. It should be noted that the strongest pigment concentration was found in M13 sediments (0.94 µg.g^{-1}), a station that behaves like the coastal marine water stations. The sediments contents of chlorophyll *a* in Batroun area are weaker than in other areas of the Mediterranean. In fact, they vary between 1.3 and 5.1 µg.g^{-1} with an annual average of 3.1 µg.g^{-1} in Marsalla's lagoon (Sicily - Western Mediterranean) (Pusceddu *et al*., 1997, 1999). Also in the gulf of Lion (France), the chlorophyll *a* contents in the sediments of Têt River's estuary (North-Western Mediterranean) are higher than in the sediments of our stations (between 0.3 and 1.2 µg.g^{-1}) (Guidi-Guilvard and Buscail, 1995).
On the other hand, the situation looks rather different for meiofauna distribution. It appears clearly that meiofauna densities were weak to very weak in stations located close to the factory. Whereas at stations located out of the dominant influence of the chemical plant, the situation was more diversified; these stations were, in general, characterized by the strongest densities of meiofauna. Among stations with sandy predominance, M1 was characterized by the presence of a big population of polychaetes (25% meiofauna populations i.e. the strongest representation of this group for all the stations). The polychaetes are often present in the sediments of polluted zones, like the proximity of urban emissaries and ports (Guerra-García and García-Gómez, 2004), and which they are considered as organic indicators of pollution (Borja et al., 2000). This strong density of polychaetes group created a certain competition with other groups by the reduction of the relative density of nematodes up to 59%. The station M13, the most distant (1.5 km offshore from the factory) and the deepest (27 m), represented another particular case since it is characterized by a strong diversification of groups and weak density (750 ind.10 cm^{-2}), associated to a predominance of harpacticoides group (52%), not found in any of the other stations. However, the coarse nature of sediments did not create a favorite habitat for meiofauna proliferation, but a favorable one for groups' diversification. It is important to note that the absence of fine fraction in M13 sediments is probably due the absence of factory's influence, or at least to its extremely limited impact. A more particular situation was met at the three stations located near the outlet of the river (M3, M4 & M5). Meiofauna density was not the highest in M4 sediments, but at both stations that surround it, M3 (4166 ind.10 cm^{-2}) in particular and M5 (2536 ind.10 cm^{-2}). It would be thought that at station M4, in front the river's mouth, the meiofauna could have found better conditions for its development because of organic matter inflows. But, other elements should be taken into account in order to explain the higher numbers of meiofauna at stations M3 and M5. As it was noted before that the sediments in front of the river's mouth (station M4) were undoubtedly subjected to very active hydrodynamics, so the fine fraction was less presented there than in stations M3 and M5. In these two stations surrounding M4, we had at the same time, the fine fraction was slightly higher and it was associated with higher densities of meiofauna. We are, probably, in the presence of "spot" of meiofauna biomasses (Tselepides and Lampadariou, 2004), being able to profit, according to dominant winds direction, of the finer particles inflows coming from the river when this one is active, and which deposit at these two stations.
The evolution between chlorophyll a and meiofauna is well illustrated in Fig. 8, where the correlation seems to be inversely highly significant (r= -0.77; P<0.01; k=10). The phytobenthic organisms are able to present a trophic source for some groups of meiofauna. This inverse relation allows observing the consequence of these processes. In fact, it could be thought that the explanation is not in that inverse relation but in the texture of the sediments. Indeed, if in figure 9, the chlorophyll a contents are plotted against the percentage of fine fraction, it can be realized that all the points, in exception of only one, are

presenting a strong alignment. This exceptional point is represented as a cross and it corresponds to station M13, which has a lack of fine fraction. At this station, the sediment is coarse cockled type and its particular richness in chlorophyll *a* can not be due to microphytobenthos, but probably to macro-algae residues. Though, taking into account its completely eccentric position, this cross-form point (M13) (figure 9) can not be considered as a part of the others, at least for these two variables (chlorophyll *a* and fine fraction). Indeed, if station M13 is drawn aside, a very highly significant positive relation (r= 0.99; P<0.001; k=7) would be obtained between fine fraction percentage and chlorophyll *a* contents.

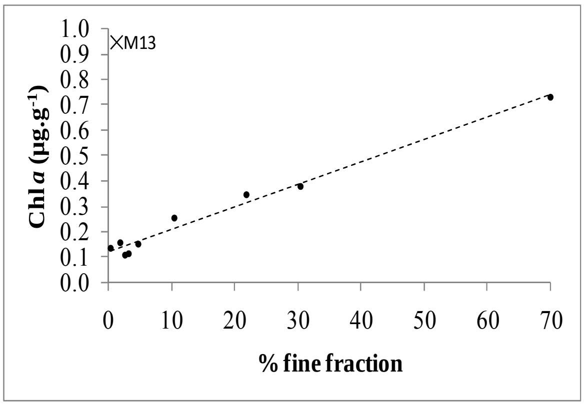

Fig. 9. Correlation between fine fraction percentage and chlorophyll a contents ($\mu g.g^{-1}$) in surfac sediments (r= 0.99; P<0.001; k=7).The dotted regression lin cannot be obtained unless if the x point (station M13) is discarded

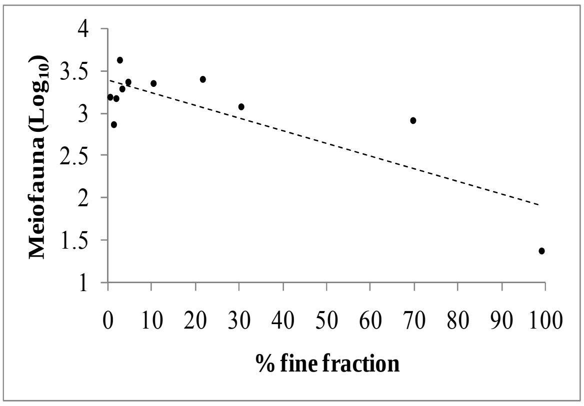

Fig. 10. Correlation between meiofauna densities ($\log_{10}$) and fine fraction percentage in surface sediments (r= -0.82; P<0.01; k=9)

On the contrary, a highly significant inverse correlation (r= -0.82; P<0.01; k=9) is established between meiofauna densities and fine fraction percentage (figure 10). This relation is weird since the literature speaks about an inverse situation, where the meiofauna abundance is positively well related to fine fraction importance (Guidi-Guilvard and Buscail, 1995; Bogut and Vidaković, 2002). In fact, the fine fraction, found at stations M7, M8 and M9, was mainly consisted of factory production residues in the form of very turbid plumes charged with fine particles. In figure 10, it is possible to distinguish two groups. In the first group with strong fine fraction, the substrate is primarily of industrial origin. In the second one with small percentage of fine fraction, the sediments are of natural resources. By plotting the group of stations (n=6) with fine fraction <10% with the corresponding meiofauna densities, it could be noticed that meiofauna densities tend to increase with the increase of fine fraction percentage. But, the coefficient of correlation (r= 0.65; k=4; p<0.05) is not however sufficient to conclude a significant relation when taking into account the low densities. Therefore, it seems that at stations located out of the factory's influence, where the sedimentary substrates are natural, a negative relation between meiofauna densities and fine fraction percentage would not be found. Though, it could be concluded that there are two samples of populations for both biological indicators: meiofauna and pigments. Once gathered together, then we could consider, as a general thought, that finer the sediments are, poorer they are in meiofauna, but richer in pigments. Thus it is the substrate composition which plays a part in the distribution of the living fraction. It should be understood that low densities of meiofauna found near the factory were not associated to the fine fraction but to the impact of pollution. However, it was shown by Darmoul and Vitiello (1980) that the phosphogypsum is harmful for living marine organisms, and that its accumulation on the bottom creates a toxic environment. On the contrary, it is not because the other stations have less fine fraction that they have more meiofauna, but because the impact of the factory there is weaker. But, could it be considered that in stations under the direct influence of the factory's emissaries (M7 and M9), the high concentrations of chlorophyll *a*, already found associated to high percentage of fine fraction, could be also associated to living organisms? The chlorophyll *a* is biodegraded quite quickly when cells are dead, except if the biological material is protected from degradation by a strongly reduced environment; however, it is the case of these stations. Moreover, taking into account the strong turbidity at these stations, we can wonder how the phytobenthos manage to develop. On the other hand, we can also think that marine phytoplankton, pushed by the currents in this zone, can die and sediment on the bottom by finding non-oxidizing conditions; there would be a certain rate of organic compounds preservation.

Conclusion

In spite of the various temporal and spatial variations reported from water measurements, the analyses of marine surface sediments (integrating medium) have globally confirmed the separation of Batroun coastal area in, at least, two zones. The first zone contains the coastal marine stations (M1, M2, M3, M4, M5, M6, M12 and M13), with similar characteristics of other places of the Lebanese littoral. The sediments of these stations are characterized by the sandy predominance and the weak presence of fine fraction, by the normally high pH values and by the non reductive conditions. In this group of stations

the meiofauna was well adapted (abundance and diversity) whereas the chlorophyll *a* concentrations were low. The second zone contains the stations located under the direct influence of Selaata fertilizers plant (M7, M8, M9 and M10) and is characterized by the dominance of the fine fraction, the low pH values, and the low oxydoreduction potential. In this zone, the meiofauna representation was strongly shrunk while the chlorophyll a concentrations were high.
As general conclusion, this study concerning the integrated media has shown that, undoubtedly, the shallow depth and the active hydrodynamic (river and waves) at the stations of the first zone have facilitated the elimination of the fine fraction, whereas the sedimentation rate, coming from the rejections of the factory at the stations of the second zone, has overcome the continuous agitations produced by the hydrodynamism. It was also demonstrated that the impact of Selaata chemical factory on benthic environment was spatially limited to its proximity, which means that it was limited to the stations located under the direct impact of the western and north-western plant's emissaries. Also it is necessary to mention that an inverse relation was established between meiofauna and chlorophyll *a* in most of both groups of stations. Apparently, grain-size composition seemed to play the major role in the distribution of living biological compounds but in fact the main factor involved in biota distribution in Batroun sediments was the toxic effect of the factory's rejections. This was detected in front of the west-northern emissary, where the industrial sedimentation, essentially represented as fine fraction mostly composed of toxic phosphogypsum, have reduced to the maximum the number of meiofauna and in the contrary has increased the concentrations of chlorophyll *a* by the fact that these fine solid rejections "trap" the marine organisms (phytoplankton or zooplankton) and inhibit their oxidation process where they die on site.

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